CLAIMS

1. A dry descaling apparatus for scale removal from a surface of a metal product comprising

at least one heating area for heating the metal product,

at least one reducing area for performing a reaction between a metal-oxide reducing gas and at least the scale,

at least one area for cooling the metal product,

first heating means for heating the metal product,

second heating means for heating the reducing gas,

means for removing reaction products from the reducing gas after reaction,

means for removing reaction products which are left on the surface of the metal product after treatment, and

means for cooling the metal product;

said dry-pickling apparatus being characterised by the fact that it comprises

first control means for fluid dynamic control of the boundary layer produced by the flow of said reducing gas over the surface of said metal product wherein said first control means are adapted for generating regular pressure oscillations comprising overpressure and depression areas, which are repeated in succession along the entire surface of said metal product,

the overpressure areas being associated with a reducing gas blowing stage the towards the surface of said metal product, and

the depression areas being associated with a reducing gas evacuation phase downstream of the blowing stage, and in that it comprises

second control means for controlling reducing gas chemical composition at the blowing stage,

means adapted for purging and recycling reducing gas after reducing operation of the scale,

third control means for controlling reducing gas temperature.

2. An apparatus as claimed in claim 1 wherein pressure is above +10 Pa in said overpressure areas and where pressure ranges above –2 Pa in absolute value in said depression areas.

3. An apparatus as claimed in claim 1 wherein said first control means comprise a

plurality of coaxial Venturi tubes placed at a reciprocal distance comprised between 10 mm and 1500 mm and having their axis positioned along the conveying direction of the metal product.

4. An apparatus as claimed in claim 1 wherein said first control means comprise a plurality of tube pairs, each tube pair consisting of a heating tube and of a Venturi tube placed downstream of the heating tube, the tubes of the tube pair having axes substantially perpendicular to the surface of said metal product and are placed at a reciprocal distance preferably comprised between 10 mm and 1500 mm.

5. An apparatus as claimed in claim 1 wherein said first control means are positioned at a distance from the surface of said metal product comprised between 2 mm and 500mm.

6. An apparatus as claimed in claim 1 wherein the first heating means comprise a microwave device.

7. An apparatus as claimed in claim 1 wherein the first heating means comprise a heating convective flow of the reducing gas previously heated to a temperature comprised between 300 °C and 1100 °C.

8. An apparatus as claimed in claim 1 wherein the first heating means comprise induction heating elements with or without frequency modulation.

9. An apparatus as claimed in claim 1 wherein the first heating means comprise air or oxygen burners having a naked or screened flame.

10. An apparatus as claimed in claim 1 wherein the first heating means comprise gas or electric radiant tubes.

11. An apparatus as claimed in claim 1 wherein the first heating means comprise amplified radiation heating elements.

12. An apparatus as claimed in claim 1 wherein the first heating means comprise a microwave and/or convective flow device for heating the reducing gas previously heated to a temperature comprised between 300 °C and 1100 °C and/or induction heating elements and/or air or oxygen burners having a naked or screened flame and/or gas or electric radiant tubes and/or amplified radiation heating elements.

13. An apparatus as claimed in claim 1 wherein said second heating means comprise at least one duct of hot refractory material through which the reducing

gas flows or at least a metal wall heated electrically or by a flame that is licked by said reducing gas.

14. An apparatus as claimed in claim 1 wherein said means for cooling the metal product comprise inert or reducing gas forced convection systems.

15. An apparatus as claimed in claim 1 wherein said means for removing the reaction products from the reducing gas, after reaction stage, comprise at least one cryogenic and/or absorption and/or mechanical plant.

16. An apparatus as claimed in claim 1 wherein said means for removing the reaction products remaining on the surface of the treated metal product are placed after the cooling area and comprise mechanical brushing means.

17. An apparatus as claimed in one or more of the previous claims wherein said heating, reducing, and cooling areas are placed in a common chamber including said first and second heating means, said first control means, and said means for cooling the metal product.

18. A dry descaling process for the removal of the scale on the surface of a metal product, which is carried out with the dry pickling apparatus as claimed in one of the previous claims comprising

at least one heating area for heating the metal product,

at least one reducing area for performing a reaction between a metal-oxide reducing gas and at least the scale,

at least one area for cooling the metal product,

first heating means for heating the metal product,

second heating means for heating the reducing gas,

means for removing reaction products from the reducing gas after reaction,

means for removing reaction products which are left on the surface of the metal product after treatment, and

means for cooling the metal product,

the process comprising the following steps:

a) providing a metal-oxide reducing gas,

b) heating the metal product to a first temperature greater than ambient temperature without reducing and without oxidizing the specific surface of the material to be treated,

c) heating the reducing gas to a second temperature greater than ambient temperature,

d) maintaining the metal product in the reducing area for a predetermined amount of time,

e) performing the reaction between said metal-oxide reducing gas and at least said scale,

f) cooling the metal product to a predetermined temperature,

g) removing the reaction products from the reducing gas after the reaction with the scale,

h) removing the reaction products from the surface of the treated metal product,

the process being characterized by:

i) controlling fluid dynamics of boundary layer of the flow of the reducing gas over the surface of the metal product in such a manner that there is provided an organised gas distribution and homogeneous gas concentrations adequate to the amount of the scale found on said surface and sufficient for removing the reaction products from said reducing gas,

j) providing a blowing stage of the heated reducing gas to the surface of said metal product at a predetermined flow rate suitable for making the gas penetrate into pores of said scale whereby said blowing stage is associated with a corresponding overpressure area on the surface of said metal product,

k) providing a predetermined reaction time adequate to remove oxygen from the scale,

l) providing, by means of the boundary layer fluid dynamic control means , an evacuation flow of said reducing gas, after it has reacted in accordance with stage k), after said delivery flow, whereby said evacuation flow is associated with a corresponding depression area on the surface of said metal product,

m) performing stages j) and l) cyclically in regular succession along the entire surface of said metal product,

n) removing the reaction products from the reducing gas after the reaction with the scale.

19. A process as claimed in claim 18 wherein the reaction products that remain on the surface of the treated metal product are removed.

20. A process as claimed in claim 18 wherein, at stage j), the concentration of reducing gas produced compared to the scale is comprised between 4 $Nm^3/(min\ kg_{scale})$ and 100 $Nm^3/(min\ kg_{scale})$.

21. A process as claimed in claim 18 wherein the pressure ranges above +10 Pa in said overpressure areas.

22. A process as claimed in claim 18 wherein in said depression areas the pressure ranges above –2 Pa in absolute value.

23. A process as claimed in claim 18 wherein the reducing gas is used pure or in combination with other inert and/or reducing gases.

24. A process as claimed in claim 18 wherein the reducing gas is hydrogen and the inert gases are preferably nitrogen and/or helium and/or argon.

25. A process as claimed in claim 18 where, in accordance with stage n), water vapor concentration is kept at every point below 5% in volume.

26. A process as claimed in claim 18 wherein the reducing gas is heated to a temperature preferably comprised between 300°C and 1100°C.

27. A process as claimed in claim 18 wherein the heating of the metal product is carried out by microwave radiation and/or a reducing gas heating convection flow and/or by induction and/or by flame and/or by radiation.

28. A process as claimed in claim 18 wherein the heating of the reducing gas is accomplished by means of contact with heated refractory materials and/or heated metal walls.

29. A process as claimed in claim 18 wherein the boundary layer fluid dynamic control of the by means of a plurality of Venturi tubes that are coaxial, placed at a reciprocal distance comprised between 10 mm and 1500 mm, and have their axis placed along the conveying direction of the metal product.

30. A process as claimed in claim 18 wherein the boundary layer fluid dynamic control of the is performed by means of a series of tube pairs wherein each tube pair consists of a heating tube and a Venturi tube placed downstream of the heating tube, wherein the tubes of the tube pair have axes substantially perpendicular to the surface of the metal product, and wherein the tubes are placed at a reciprocal distance comprised between 10 mm and 1500 mm.

31. A process as claimed in claim 18 wherein the removal of the reaction products

from the reducing gas after reaction is performed by means of a cryogenic and/or absorption and/or mechanical effect.

32. A process as claimed in claim 18 wherein the cooling of said metal product is performed by means of inert gas forced convection.

33. A process as claimed in claim 18 and 30 comprising a step for reinjecting the reducing gas, after the reaction products have been removed, into the cycle.

34. A process as claimed in claim 19 wherein the reaction products found on the surface of said metal product are removed by brushing.